Total Maximum Daily Loads of Pathogen for Finney Creek in Accomack County, Virginia

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Draft

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List of Abbreviations

BMP	Best Management Plan
CFR	Code of Federal Regulations
CWA	Clean Water Act
DGIF	Department of Game and Inland Fisheries
EFDC	Environmental Fluid Dynamics Computer Code
EPA	Environmental Protection Agency
FA	Future Allocation
GIS	Geographic Information System
LA	Load Allocation
LSPC	Loading Simulation Program C++
MOS	Margin of Safety
MOU	Memorandum of Understanding
MS4s	Municipal Separate Storm Sewer Systems
NLCD	National Land Cover Data
NPDES	National Pollutant Discharge Elimination System
SWCB	State Water Control Board
TMDL	Total Maximum Daily Load
USCB	United States Census Bureau
USDA	United States Department of Agriculture
USFWS	US Fish and Wildlife Service
USGS	United States Geological Survey
VA-DCR	Virginia Department of Conservation and Recreation
VA-DEQ	Virginia Department of Environmental Quality
VADGIF	Virginia Department of Game and Inland Fisheries
VDH	Virginia Department of Health
VPDES	Virginia Pollutant Discharge Elimination System
WLA	Wasteload Allocation
WQAIR	Water Quality Assessment Integrated Report
WQC	Water Quality Criteria
WQLS	Water Quality Limited Segments
WQMIRA	Water Quality Monitoring, Information, and Restoration Act
WQMP	Water Quality Management Plans
WQS	Water Quality Standard

EXECUTIVE SUMMARY

Introduction

Section 303(d) of the Clean Water Act (CWA) and the United States Environmental Protection Agency's (USEPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop total maximum daily loads (TMDLs) for waterbodies that are exceeding water quality standards (WQSs). TMDLs represent the total pollutant loading that a waterbody can receive without violating WQSs. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollution sources and in-stream water quality conditions. By following the TMDL process, states can establish controls based on water quality conditions to reduce pollution from both point and nonpoint sources to restore and maintain the quality of their water resources.

Finney Creek is located in Accomack County, Virginia, along the Eastern Shore of the Delmarva Peninsula. The Creek drains east to the Hummock Cove, which drains directly east to the Atlantic Ocean. Finney Creek-Upper (VAT-D03E_FNC01A04) was listed on the 2006 Virginia 305(b)/303(d) Water Quality Assessment Integrated Report (VA-DEQ, 2006) as an impaired waterbody due to violation of the State's water quality standard for enterococci. Based on the water quality assessment, it does not support its designated use of primary contact recreation (e.g., swimming and fishing). TMDL has been developed to meet enterococci standards. This document, upon approval of EPA, establishes a pathogen (Enterococci) TMDL for Finney Creek-Upper.

Assessment Unit	Water name	Location Description	Cause Category	Cause Name	Size (miles)
VAT-D03E_FNC01A04	Finney Creek - Upper	Tributary to Hummock Cove, station located near Lucasville. Upper portion upstream of widening (approx. RM 2.38). No DSS shellfish direct harvesting condemnation.	5A	Fecal Coliform	0.04

Sources of Enterococci

The watershed approach was applied to conduct the source assessment. There is no point source such as a wastewater treatment plant (WWTP) in the Finney Creek watershed. The potential sources of pathogens in the watershed are nonpoint sources, including livestock, wildlife, land application of biosolids, pets, failing septic systems, and uncontrolled discharges (straight pipes conveying gray water from kitchen and laundry areas of private homes, etc.).

Modeling Approach

A system of numerical models was applied to simulate the loadings of organic matter and nutrients, as well as pathogens (enterococci) from the Finney Creek watershed, and the resulting response of in-stream water quality variables. The watershed model, Loading

Simulation Program in C^{++} (LSPC), developed by the USEPA, was selected to simulate the watershed hydrology and pathogen load to Finney Creek. The Environmental Fluid Dynamics Computer Code (EFDC) was used to simulate the transport and fate of enterococci in the receiving water.

Endpoints

The numerical criteria for enterococci are a *Geometric Mean* of 35 CFU /100mL and a *Single Sample Maximum* of 104 CFU /100mL. The endpoints were established based on the designated use of primary contact recreation (e.g., swimming and fishing).

Load Allocation Scenarios

For the recreational use impairment, the appropriate water quality standard was determined to be a monthly geometric mean value of 35 CFU/100 ml and a Single Sample Maximum of 104 CFU /100mL for enterococci. Calibrated mode simulation results were used to establish the existing loads in the system. The loads that are necessary to meet water quality standards were established for the TMDLs. The difference between the TMDL and the existing loading (annual based loading) represents the necessary level of reduction. Because of the tidal effect, bacteria discharged from the adjacent watershed, Rattrap Creek, can be transported to the Finney Creek as well. Therefore, load reduction is needed to meet water quality criterion in both watersheds. The maximum reductions required to meet enterococci water quality standard is approximately 69% for Finney Creek-Upper and Rattrap Creek watersheds. The enterococci TMDLs are summarized below:

Waterbody Name		**TMDL**	=	**LA**	+	**WLA**	+	**FA**	+	**MOS (5%)**
Finney Creek-Upper	Enterococci	7.97×10^{9}		7.49×10^{9}		n/a		7.97×10^{7}		3.98×10^{8}
Rattrap Creek	Enterococci	2.08×10^{10}		1.95×10^{10}		n/a		2.08×10^{8}		1.04×10^{9}

Where:

TMDL =Total Maximum Daily Load
LA = Load Allocation (nonpoint source)
WLA =Wasteload Allocation (Point source)
FA =Future Allocation, which is 1% of allowable load
MOS =Margin of Safety

Finally the results of the enterococci loading for each source category estimated by the watershed approach were used to partition the load allocation (LA) that would meet water quality standards according to sources, as summarized below:

Waterbody Name	Category	Current Load (Counts/Day)	Load Allocation (Counts/Day)	Reduction Needed (%)
Finney Creek-Upper	**Livestock**	2.67E+09	0.00E+00	100.0%
	Wildlife	2.41E+10	7.97E+09	67.0%
	Human	3.94E+06	0.00E+00	100.0%
	Pets	3.26E+08	0.00E+00	100.0%
	Total	2.71E+10	7.97E+09	70.6%
Rattrap Creek	**Livestock**	7.02E+09	0.00E+00	100.0%
	Wildlife	5.65E+10	2.08E+10	63.3%
	Human	9.23E+06	0.00E+00	100.0%
	Pets	7.64E+08	0.00E+00	100.0%
	Total	6.43E+10	2.08E+10	67.7%

Margin of Safety

EPA regulations at 40 CFR 130.7 (c)(1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. This was done in this study by using of a long-term water quality data that cover different flow regimes and temperatures, and a long-term simulation to estimate the current bacteria loads and load reduction targets. To allocate loads while protecting the aquatic environment, a margin of safety (MOS) needs to be considered. For Finney Creek-Upper, an explicit MOS of 5% was included in the TMDLs.

Recommendations for TMDL Implementation

The goal of this TMDL is to develop an allocation plan that achieves water quality standards during the implementation phase. Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (WQMIRA) states, in Section 62.1-44.19.7, that the "Board shall develop and implement a plan to achieve fully supporting status for impaired waters".

The TMDL developed for the Finney Creek watershed impairments provides allocation scenarios that will be a starting point for developing implementation strategies. Additional monitoring aimed at targeting the necessary reductions is critical to implementation development. Once established, continued monitoring will aid in tracking success toward meeting water quality milestones.

Public participation is critical to the implementation process. Reductions in non-point source loading are the crucial factor in addressing the problem. These sources cannot be addressed without public understanding of, and support for, the implementation process. Stakeholder input will be critical from the onset of the implementation process in order to develop an implementation plan that will be truly effective.

Public Participation

Public participation was elicited at every stage of the TMDL development in order to receive inputs from stakeholders and to apprise the stakeholders of the progress made. A public meeting was organized for this purpose. The first public meeting was held on March 28, 2012 at Accomack-Northampton Planning District Commission, to inform the stakeholders of TMDL development process and to obtain feedback. Results of the hydrologic calibration, bacteria source estimates, and TMDL development were discussed in the public meeting. The second public meeting was held on July 18, 2012 at Accomack-Northampton Planning District Commission. Updated bacterial loading distribution and TMDL results were presented and discussed in the public meeting.

1.0 INTRODUCTION

1.1 Background

Section 303(d) of the Clean Water Act and the United States Environmental Protection Agency's (USEPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies which are exceeding Water Quality Standards (WQSs). TMDLs represent the total pollutant loading that a waterbody can receive without violating WQSs. The TMDL process establishes the allowable loadings of pollutants for a waterbody that the waterbody can receive without violating WQSs. By following the TMDL process, states can establish controls based on water quality conditions to reduce pollution from both point and nonpoint sources to restore and maintain the quality of their water resources.

Finney Creek is located in Accomack County, Virginia, along the Eastern Shore of the Delmarva Peninsula. The Creek drains east to the Hummock Cove, which drains directly east to the Atlantic Ocean. Finney Creek -Upper (VAT-D03E_FNC01A04) was listed on the 2006 Virginia 305(b)/303(d) Water Quality Assessment Integrated Report (VA-DEQ, 2006) as an impaired waterbody due to violation of the State's water quality standard for enterococci. Based on the water quality assessment, it does not support its designated use of primary contact recreation (e.g., swimming and fishing). A TMDL has been developed to meet enterococci standards. This document, upon approval of EPA, establishes a pathogen (enterococci) TMDL for Finney Creek-Upper.

1.2 Listing of Waterbodies under the CWA

WQSs are regulations based on federal or state law that set numeric or narrative limits on pollutants. Water quality monitoring is performed to measure pollutants and determine if the measured levels are within the bounds of the limits set for the uses designated for the waterbody. Waterbodies with pollutant levels that exceed the designated standards are considered impaired for the corresponding designated use (e.g. swimming, drinking, shellfish harvest, etc.). Under the provisions of §303 (d) of the Clean Water Act (CWA), impaired waterways are placed on the list reported to the EPA. The impaired water list is included in the biennial 305(b)/ 303(d) Water Quality Assessment Integrated Report (WQAIR, VA-DEQ, 2006). Those waters placed on the list require the development of a TMDL and corresponding implementation plan intended to eliminate the impairment and bring the water into compliance with the designated standards.

1.3 Watershed Location and Description

Finney Creek is located in Accomack County, along the Eastern Shore of the Delmarva Peninsula, Virginia (Figure 1.1). The watershed area for Finney Creek is 25.9 km^2 (6,391.6 acres) in size. The sub-watershed area of Finney Creek–Upper accounts for 26% of the total watershed area. The Finney Creek watershed is mainly forested, agricultural, and covered by wetlands. These land uses account for approximately 98%. Finney Creek can be delineated to two portions, which are Finney Creek-Upper and Finney Creek-Lower. The portion of concern is the upper part, which drains east to the lower portion of Finney Creek. Rattrap Creek is a tributary that discharges into Finney Creek-Lower and eventually drains to the Atlantic Ocean (Figure 1.2).

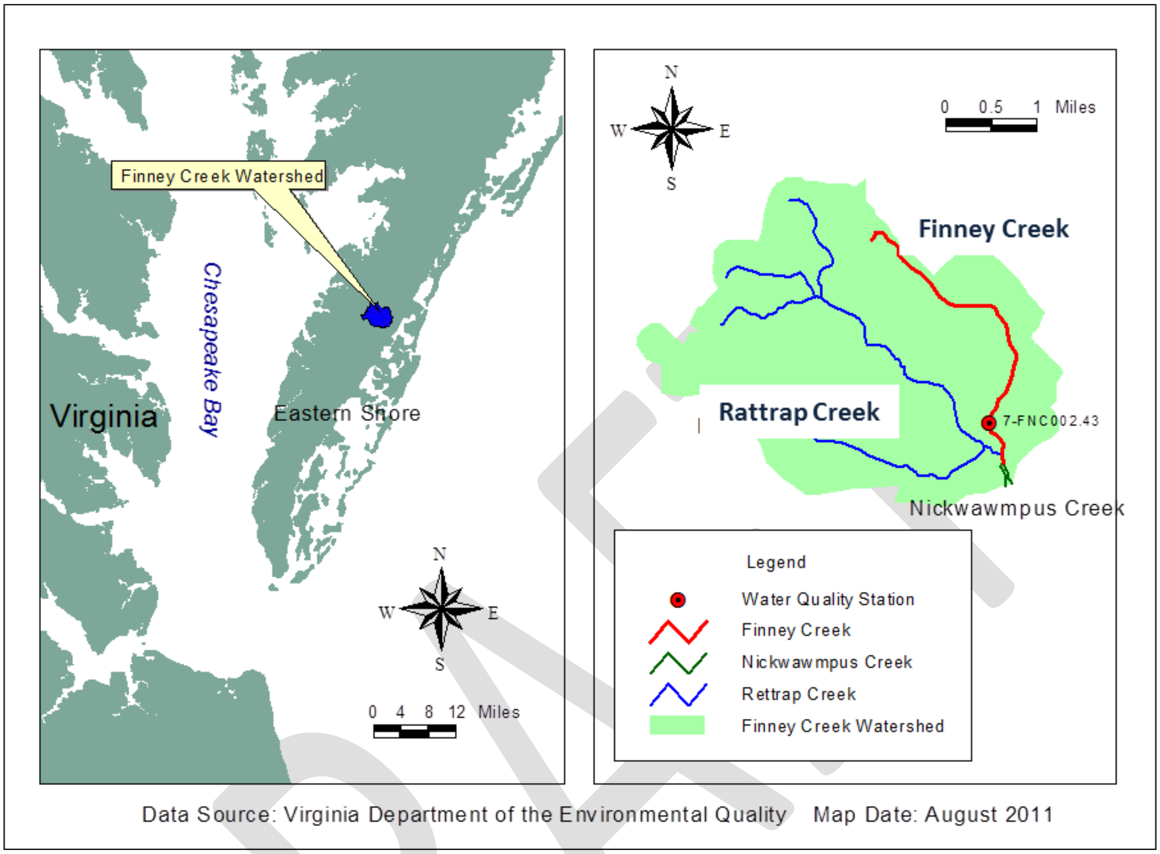

Figure 1.1: Location Map of Finney Creek, the Impacted Segments, and the Water Quality Stations

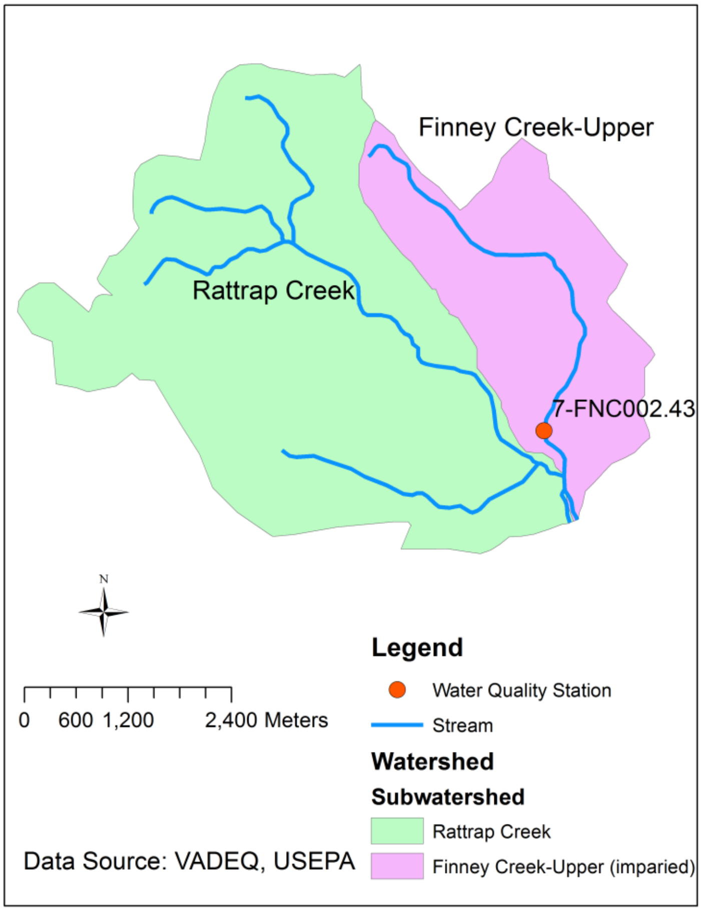

Figure 1.2: Delineation of the upper portion of Finney Creek Sub-watershed and Rattrap Creek Sub-watershed (Upper Finney Creek is impaired segment)

1.4 Designated Uses and Applicable Water Quality Standard

1.4.1 Designation of Uses

According to Virginia WQSs (9VAC25-260-10):

"All State waters, including wetlands, are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish."

The state promulgates standards to protect waters to ensure the uses designated for those waters are met. In Virginia's WQSs, certain standards are assigned by water class, while other standards are assigned to specifically described waterbodies/waterways to protect designated uses of those waters. Virginia has seven waters classes (I through VII) with DO, pH, and temperature criteria for each class (9VAC25-260-50). The identification of waters by class is found in the river basins section tables. The tables delineate the class of waters to which the basin section belongs in accordance with the class descriptions given in 9VAC25-260-50. By finding the class of waters for a basin section in the classification column and referring to 9VAC25-260-50, the DO, pH, and maximum temperature criteria can be found for each basin section. Finney Creek is considered as a Class II water, "Estuarine Water (Tidal Water-Coastal Zone to Fall Line)" (9VAC25-260-50).

Figure 1.2 illustrates the delineation of the impaired segments. The upper portion of Finney Creek do not support the recreational designated use due to violations of enterococci criteria.

1.4.2 Bacteria Standard

Effective February 1, 2010, VADEQ specified a new bacteria standard in 9 VAC 25-260-170.A. These standards replaced the existing fecal coliform standard of 9 VAC 25-260-170. For a non-shellfish supporting waterbody to be in compliance with Virginia bacteria standards for primary contact recreation in a saltwater or transition zone, the current criteria are as follows:

"Enterococci bacteria shall not exceed a monthly geometric mean of 35 cfu/100 ml in transition and saltwater. If there are insufficient data to calculate monthly geometric means in transition and saltwater, no more than 10% of the total samples in the assessment period shall exceed enterococci 104 cfu/100 ml."

1.5 Impairment Listing

The VA-DEQ has one water quality station (7-FNC002.43) in the upper reach of Finney Creek-Upper (See Figure 1.2 for station location). *Enterococci* were measured during 2001-2003.

Sufficient exceedances of Virginia's WQSs for enterococci maximum were recorded at the station to assess the segments of Finney Creek-Upper as not supporting of the CWA's aquatic life and recreation use support goal in Table 1.1. The designated uses, impairments, and criteria for Finney Creek-Upper segments are summarized in Table 1.2.

Table 1.1: Exceedances of the Water Quality Criteria (2001-2003) of Finney Creek-Upper

Stream Name	Station ID	Impairment	Number of Samples	Number of Exceedances	Percentage Exceedance
Finney Creek-Upper	7-FNC002.43	Enterococci	10	2	20%

Table 1.2: The Water Types, Designated Uses, Impairments, WQC, and List Years for Finney Creek

Stream Name	Water Type	Designated Use	Impairment	Criteria	List Year
Finney Creek-Upper	Tidal	Recreation	Enterococci	Maximum <104 (Count/100ml)	2001 ~2003

2.0 WATERSHED CHARACTERIZATION

2.1 Topology, Soil, and Climate

The Finney Creek watershed, located along Virginia's Eastern Shore, is in the lowland sub-province of the Coastal Plain province. Latest Tertiary and Quaternary sand, silt, and clay, which cover much of the Coastal Plain, were deposited during interglacial highstands of the sea under conditions similar to those that exist in the modern Chesapeake Bay and its tidal tributaries (http://www.wm.edu/geology/virginia/provinces/coastalplain/coastal_plain.html). The soils in the watershed range from moderately drained to slow infiltration rate (USDA 2006)

As part of the Tidewater Climate Region, the Finney Creek watershed experiences average January temperatures of 35-48° F and average July temperatures of 71-85° F. Average annual precipitation is 41.3 inches. It is influenced by stream discharge, groundwater seepage, and surface runoff.

2.2 Landuse

The land use characterization for the entire Finney Creek watershed was based on land cover data from the Virginia National Land Cover Data (NLCD) 2001 Land Use Dataset (Figure 2.1). Brief descriptions of land use classifications in the watershed, areas, and percentages are presented in Table 2.1. Dominant land uses in the watershed were found to be forest (43.48%) and agriculture (51.14%), which account for 94.6% of the total area in the watershed. The sub-watershed of upper Finney Creek accounts for 26%. Figure

2.2 depicts the percentage land uses within the entire watershed included Finney Creek and Rattrap Creek. Figure 2.3 shows the percentage land uses of Finney Creek sub-watersheds.

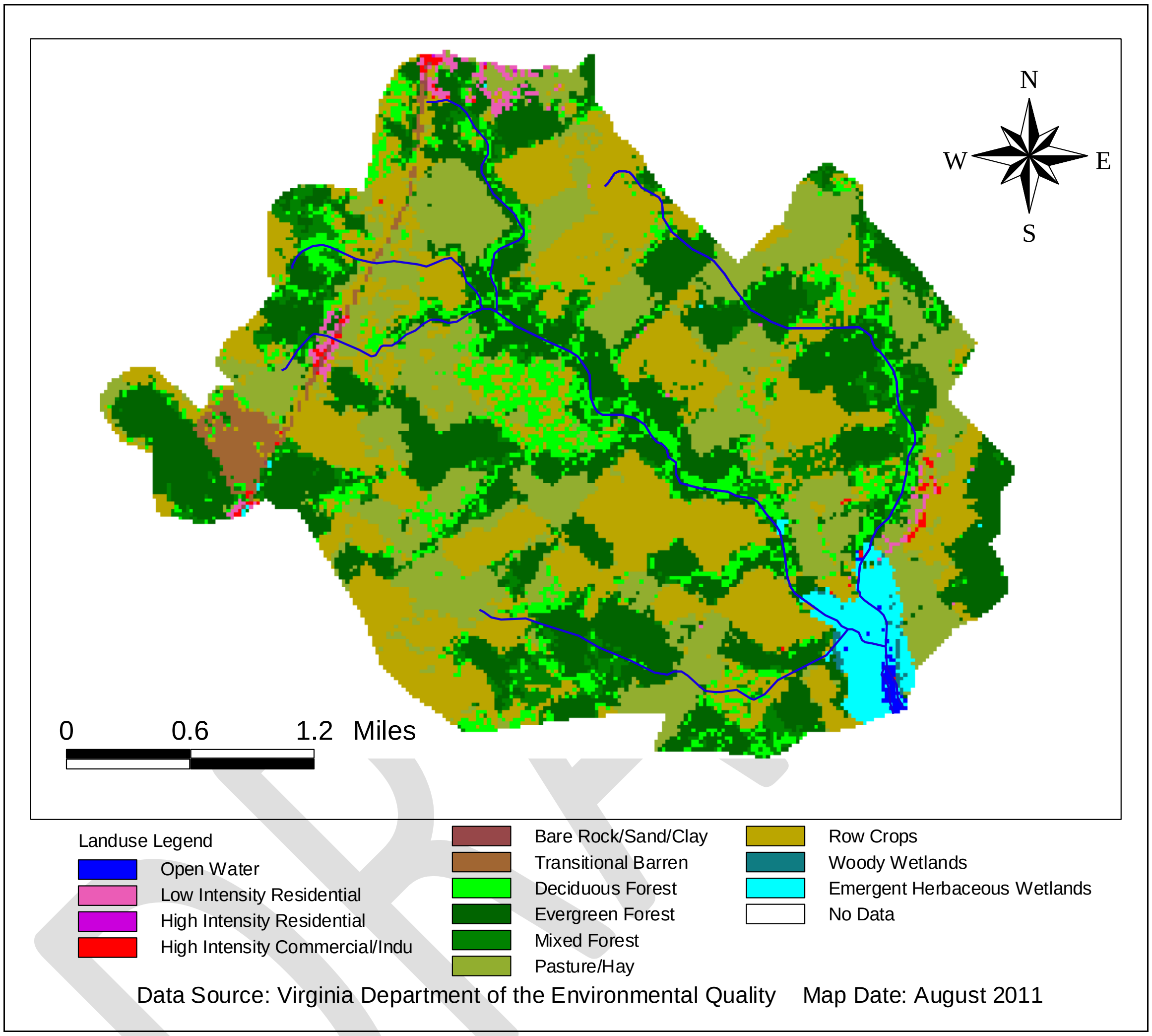

Figure 2.1: Land Use of the Finney Creek Watershed

Table 2.1: Landuse Descriptions and Percentages of the Finney Creek and Rattrap Creek Watershed

General Landuse	Landuse Name	Square Meters	Acres	% of Watershed	Total %
Finney Creek Watershed (Upper Finney Creek and Rattrap Creek)					
Forest	Deciduous Forest	2,442,600	603.3	9.44	43.48
	Mixed Forest	1,866,600	461.1	7.21	
	Evergreen Forest	6,941,700	1,714.6	26.83	
Agriculture	Row Crops	7,445,700	1,839.1	28.77	51.14

	Pasture/Hay	5,788,800	1,429.8	22.37	
Water/ Wetlands	Open Water	55,800	13.8	0.22	2.73
	Emergent Herbaceous Wetlands	609,300	150.5	2.35	
	Woody Wetlands	42,300	10.4	0.16	
Developed	Low Intensity Residential	217,800	53.8	0.84	1.14
	Commercial/Industrial/ Transportation	79,200	19.6	0.30	
Barren	Bare Rock/Sand/Clay	18,900	4.7	0.07	1.49
	Transitional Barren	368,100	90.9	1.42	
	Total	**25,876,800**	**6,391.6**	**100**	**100**
Upper Finney Creek Subwatershed					
Forest	Deciduous Forest	460,800	113.8	6.84	41.26
	Mixed Forest	548,100	135.4	8.14	
	Evergreen Forest	1,769,400	437.0	26.28	
Agriculture	Row Crops	1,786,500	441.3	26.53	53.71
	Pasture/Hay	1,829,700	451.9	27.18	
Water/ Wetlands	Open Water	16,200	4.0	0.24	4.08
	Emergent Herbaceous Wetlands	240,300	59.4	3.57	
	Woody Wetlands	18,000	4.4	0.27	
Developed	Low Intensity Residential	34,200	8.4	0.51	0.94
	Commercial/Industrial/ Transportation	28,800	7.1	0.43	
Barren	Transitional Barren	900	0.2	0.01	0.01
	Total	**6,732,900**	**1662.9**	**100**	**100**

Description of Landuse

(1) Deciduous Forest: Areas dominated by trees where 75% or more of the tree species shed foliage simultaneously in response to seasonal change.

(2) Mixed Forest: Areas dominated by trees where neither deciduous nor evergreen species represent more than 75% of the cover present.

(3) Evergreen Forest: Areas characterized by trees where 75% or more of the tree species maintain their leaves all year; Canopy is never without green foliage.

(4) Row Crops: Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton)

(5) Pasture/Hay: Areas of grasses, legumes, or grass-legume mixtures planted for livestock gra-zing or the production of seed or hay crops)

(6) Open Water: Areas of open water, generally with less than 25% or greater cover of water)

(7) Emergent Herbaceous Wetlands: Areas where perennial herbaceous vegetation accounts for 75-100% of the cover and the soil or substrate is periodically saturated with or covered with water)

(8) Woody Wetlands: Areas where forest or shrubland vegetation accounts for 25-100% of the cover and the soil or substrate is periodically saturated with or covered with water)

(9) Low Intensity Residential: Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80% of the cover. Vegetation may account for 20-70% of the cover. These areas most commonly include single-family housing units. Population densities will be

lower than in high intensity residential areas)
(10) Commercial/Industrial/Transportation: Includes infrastructure (e.g. roads, railroads, etc.) and all highways and all developed areas not classified as High Intensity Residential

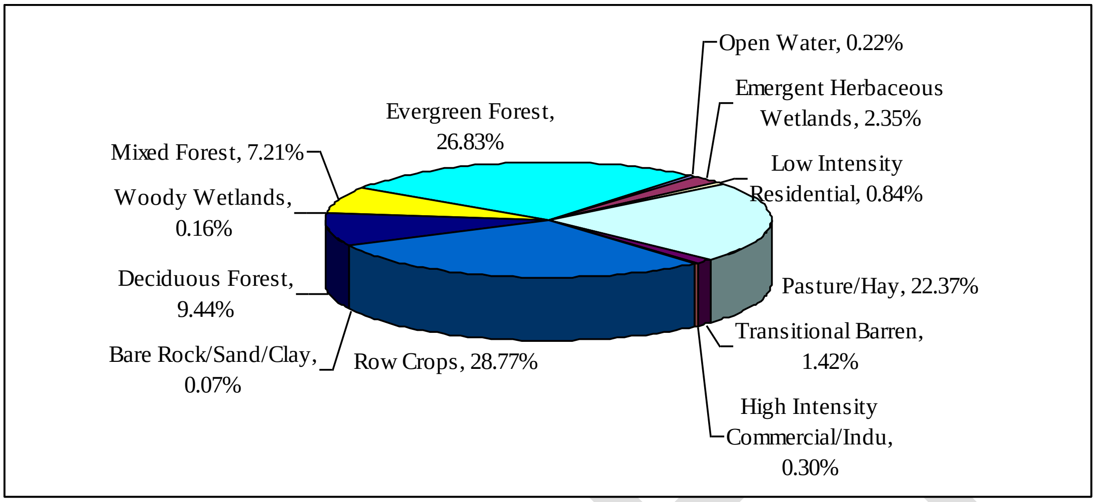

Figure 2.2: Percentage Landuses of the Finney Creek (Upper Finney and Rattrap) Watershed

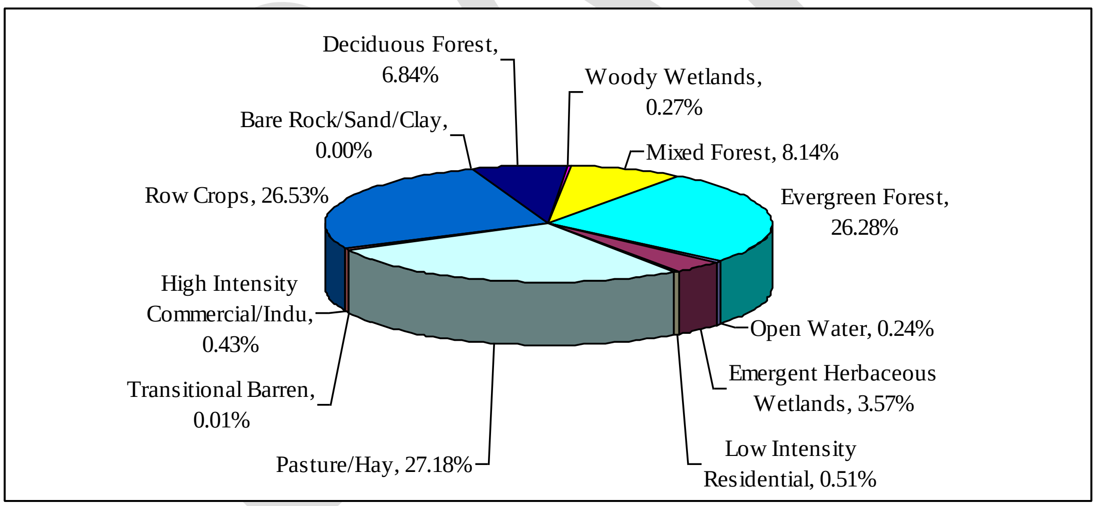

Figure 2.3: Percentage Landuses of the Upper Finney Creek Sub-watershed

2.3 Water Quality Conditions

The VA-DEQ performs water quality monitoring throughout Virginia to determine if WQSs are being met for the designated uses of the corresponding waters. Samples have been taken at the water quality monitoring station (7-FNC002.43) in Finney Creek-Upper (Figure 2.1). A summary of the data is listed in Table 2.2.

Fecal bacteria, *E. coli*, and enterococci, have been used as indicator organisms for predicting human health impacts in TMDL studies. A statistical analysis found that the highest correlation to gastrointestinal illness was linked to elevated levels of *E. coli* and enterococci in freshwater (enterococci in salt water). Currently VA-DEQ analyzes the fecal coliform, enterococci, and *E. coli* concentrations in water samples by using the membrane filtration method. This method usually has a maximum detection limit of 8,000 counts/100 ml, but the upper limit can be increased to 16,000 counts/100 ml if concentrations are expected to be high. The minimum detection limits for fecal coliform, enterococci, and *E. coli* are 100, 10, and 25 counts/100 ml, respectively. Enterococci were measured in the Creek (Table 2.2) together with pH, salinity, and temperature shown in Figure 2.4.

Table 2.2: The Observations in upper portion of Finney Creek

Station	Latitude	Longitude	Parameter	Date	# of Observations
7-FNC002.43	37.65125	-75.68253	Enterococci	09/2001-05/2003	10
			pH	09/2001-05/2003	11
			Salinity	09/2001-05/2003	11
			Temperature	09/2001-05/2003	11

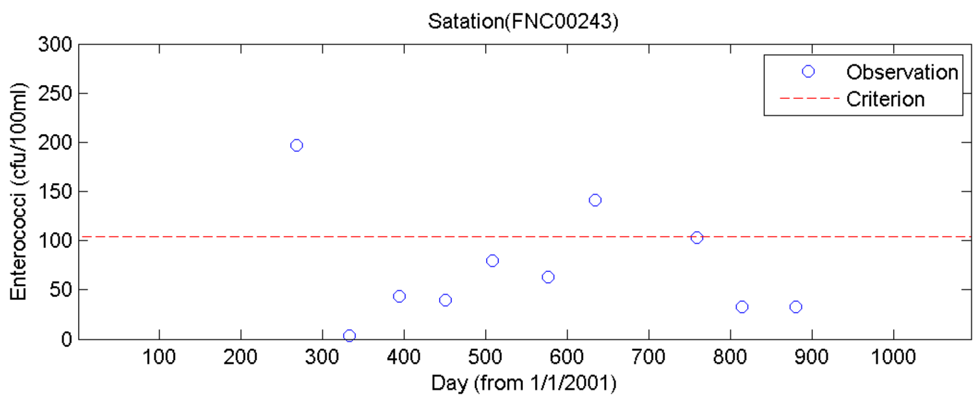

Figure 2.4: Enterococci Distribution from 2001 to 2003 at Station 7-FNC002.43 (the red line indicates the water quality standard).

2.3.1 Temperature, Salinity, and pH

pH values, temperature, and salinity for the upper portion of Finney Creek are shown in Figures 2.5-2.7. The pH values varied between 6.3 and 7.0 in the Finney Creek. The minimal value slightly exceeded the lower limit of optimum range of 6.5-9.0 for fish and other aquatic life, indicating that slowed growth of some species may occur (Boyd, 2000). A wide seasonal temperature variation is typical in the stream. Summer temperatures reached 30 degrees C and winter low temperatures were about 0 degrees C. In the upper portion to Finney Creek, most of the salinities were below 5 ppt, the peak value is more than 20 ppt. (Figure 2.7). Salinity ranges from 0.2-20 ppt, which indicates that tide can affect the upper portion of the Finney Creek. It is noted that the highest bacteria concentration corresponds to the highest salinity.

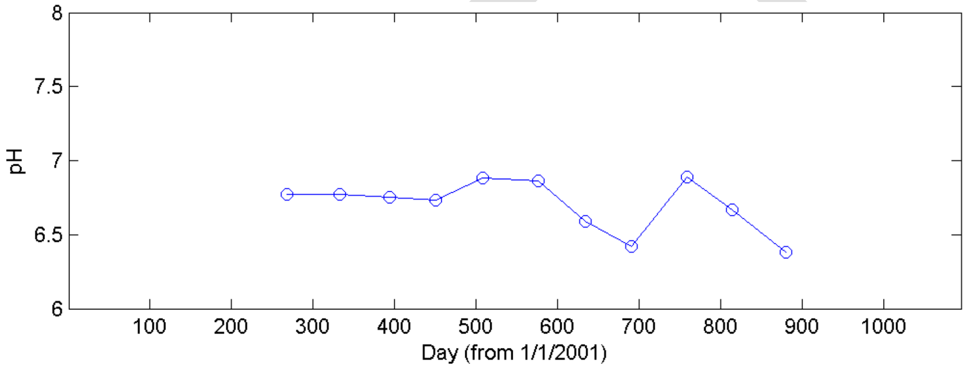

Figure 2.5: pH Values at Station 7-FNC002.43 located in upper portion of Finney Creek

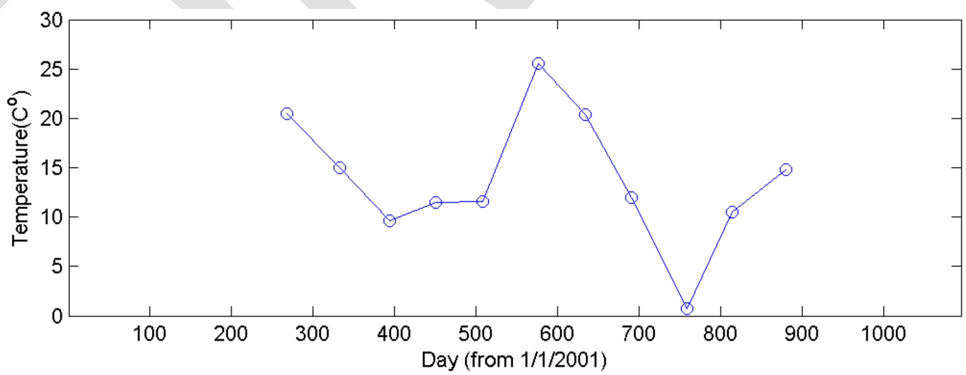

Figure 2.6: Temperature Variations at Station 7-FNC002.43 located in upper portion of Finney Creek

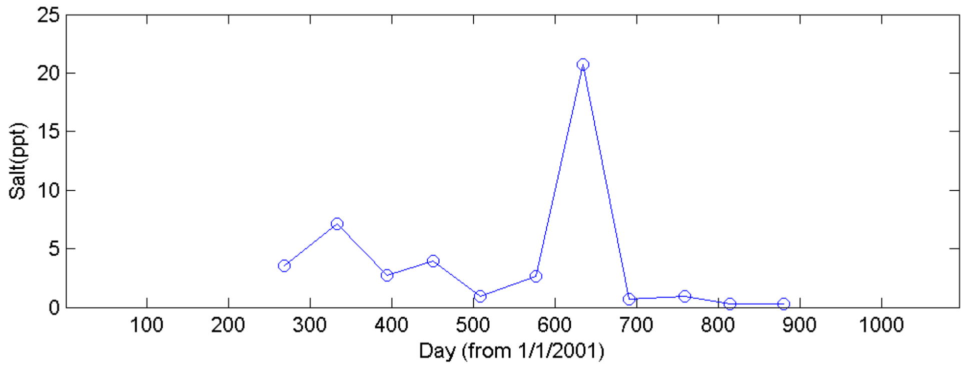

Figure 2.7: Salinity Variations at Station 7-FNC002.43 located in upper portion of Finney Creek

3.0 SOURCE ASSESSMENT

3.1 General

A primary component of pathogens TMDL development for Finney Creek is the evaluation of potential sources of pathogens in the watershed. The watershed approach was applied for the source assessment. Landuse data together with human population, wildlife, manure application etc. were used for the assessment. Sources of information that were used in evaluating potential pollutant sources included the VA-DEQ, the Virginia Department of Conservation and Recreation (VA-DCR), the Virginia Department of Game and Inland Fisheries (VADGIF), the Virginia Department of Health (VDH), US Department of Agriculture (USDA) agriculture census data, public participation, watershed studies, stream monitoring, published information, and best professional judgment.

The potential pollutant sources in the watershed can be broken down into point and nonpoint sources. Point sources are permitted pollutant loads derived from individual sources and discharged at specific locations. There is no known point source within the Finney Creek watershed. Nonpoint sources are from various sources over a relatively large land area, which are the dominant pollutant sources in the watershed.

3.2 Population Number Summaries

Population numbers for humans, dogs, livestock, and wildlife are shown in Table 3.1. The human population was derived from US Census Bureau data (US Census Bureau, 2010) and estimated based on watershed area and landuses for the Finney Creek watershed with respect to the county watershed area for urban landuse. National Agriculture Statistics Survey data were used to calculate the livestock values. The population number calculation details are described in Appendix B. Bacteria source distribution is estimated based on number of animals, typical animal weights, and daily bacteria production rates. According to field survey, deer and geese population are much higher in this watershed than averaged density in this region. Therefore, high acreage densities of 0.094, 0.04, and 0.004 animals per acre were used to estimate deer, residential geese, and Canada geese, respectively. Although a large number of chickens were estimated based on landuse and the agriculture census, there is no manure application in this watershed based on DEQ's survey. Therefore, only a small percentage of the contribution from chicken farms was estimated. The source distributions are listed in Table 3.2. It can be seen that a large portion of bacteria sources are from wildlife.

Table 3.1: Humans, Dogs, Livestock, and Wildlife Populations in Finney Creek

		Finney Creek watershed	**Rattrap Creek watershed**	**Entire watershed**
Humans		200	528	728
Dogs		56	149	205
Cat(unused)**		63	168	231
Livestock	Cattle	5	13	18
	Swine	0	0	0
	Chickens*	64473	198926	263399
	Horses	3	5	8
	Sheep	2	5	7
Wildlife	Canada Geese/Snow geese	7	19	26
	Residential Geese	70	186	141
	Deer	163	430	741
	Raccoons	34	81	115
	Muskrat	109	231	340
	Others	0	0	0

*Number was estimated based on landuse data. No manual application in this watershed.

Table 3.2: Bacteria Source Distributions

Waterbody Name	Source	Percent of Source
Upper Finney Creek	**Livestock**	9.85%
	Wildlife	88.94%
	Human	0.01%
	Pets	1.20%
	Total	100.00%
Rattrap Creek	**Livestock**	10.92%
	Wildlife	87.88%
	Human	0.01%
	Pets	1.19%
	Total	100.00%

3.3 Septic System Inputs

Conventional septic tank systems are only effective where the soil is adequately porous to allow percolation of liquids, and the groundwater level is low enough to avoid contamination. Leaking pipes or treatment tanks (i.e., leakage losses) can allow wastewater to return to the groundwater, or discharge to the surface, without adequate treatment. Leaking septic systems are a source of nutrients and bacteria. There are a total of 319 septic systems in the Finney Creek watershed (Figure 3.1). Using a failure rate of 12% based on data from the Eastern Shore region and the literature, the number of failed systems is approximately 38.

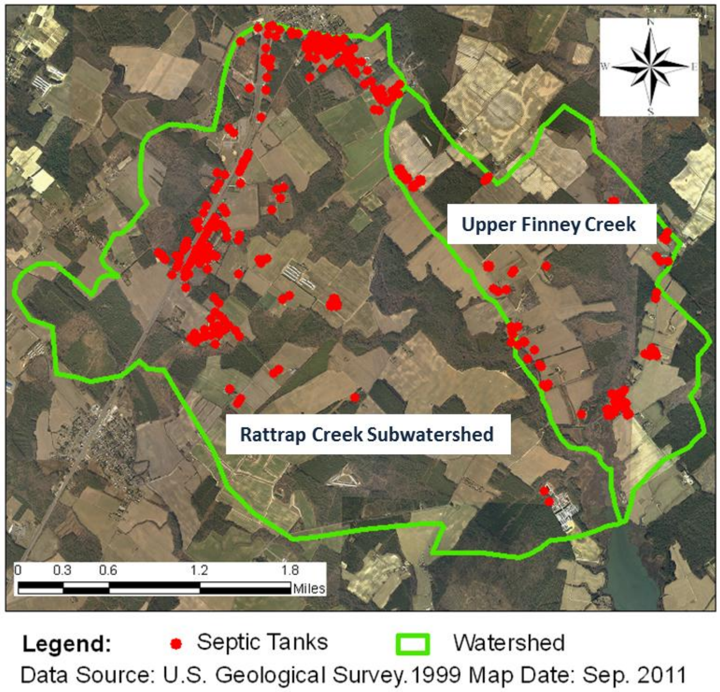

Figure 3.1: Septic System Locations in the Finney Creek Watershed

4.0 TMDL DEVELOPMENT

4.1 Overview

A TMDL is the total amount of a pollutant that a waterbody can receive and still meet WQSs. A TMDL may be expressed as a "mass per unit time, toxicity, or other appropriate measure" (CFR, 2006b). These loads are based on an averaging period that is defined by the specific WQSs. A TMDL is the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources, incorporating natural background levels. The TMDL must, either implicitly or explicitly, include a margin of safety (MOS) that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody, and in the scientific and technical understanding of water quality in natural systems. In addition, when applicable, the TMDL may include a future allocation (FA) when necessary. This definition is denoted by the following equation:

$$\text{TMDL} = \text{WLAs} + \text{LAs} + \text{MOS} + (\text{FA, where applicable})$$

This section documents the detailed DO and enterococci TMDLs and LA development for Finney Creek.

4.2 Selection of a TMDL Endpoint

An important step in developing the TMDL is the establishment of in-stream numerical endpoints, which are used to evaluate the attainment of acceptable water quality and allowable loading capacity. According to WQS 9VAC25-260-50, the numerical criteria for enterococci for the recreational use of Finney Creek-Upper is a *Geometric Mean* of 35 counts/100mL and a *Single Sample Maximum* of 104 counts/100ml. Because a *Single Sample Maximum* of 104 counts/100ml is more stringent, it was used as the endpoint for enterococci to determine the TMDL.

4.3 Model Development for Computing TMDL

Numerical models are a widely used approach for TMDL and other water quality studies. In this study, a system of numerical models was applied to simulate the loadings of bacteria and the resulting response of in-stream bacteria. The modeling system consists of two individual model components: the watershed model and the hydrodynamic-water quality model. The watershed model Loading Simulation Program in C^{++} (LSPC), developed by the USEPA (Shen *et al.*, 2005), was selected to simulate the watershed hydrology and bacteria loadings in the watershed. The Environmental Fluid Dynamics Computer Code (EFDC) (Hamrick 1992a; Park *et al.*, 1995) was used to simulate bacteria transport in the receiving water. A detailed model description, model setup, model calibration, and scenario runs are presented in Appendix A.

The LSPC model is driven by hourly precipitation and was used to simulate the freshwater flow and its associated nonpoint source pollutants. The simulated freshwater flow and bacteria loadings from each sub-watershed were fed into the adjacent water quality model segments. The EFDC model simulates the transport and fate of bacteria in the Creek.

The flow simulated by the watershed model was calibrated using USGS gauging data at Gage 01484800 in Guy Creek near Nassawadox, VA, located approximately 14.8 miles south of the Finney Creek watershed. This is the only USGS gauging station located on the Eastern Shore. An example of model calibration of the flow is shown in Figure 4.1. Detailed modeling processes and calibration procedure are presented in Appendix A.

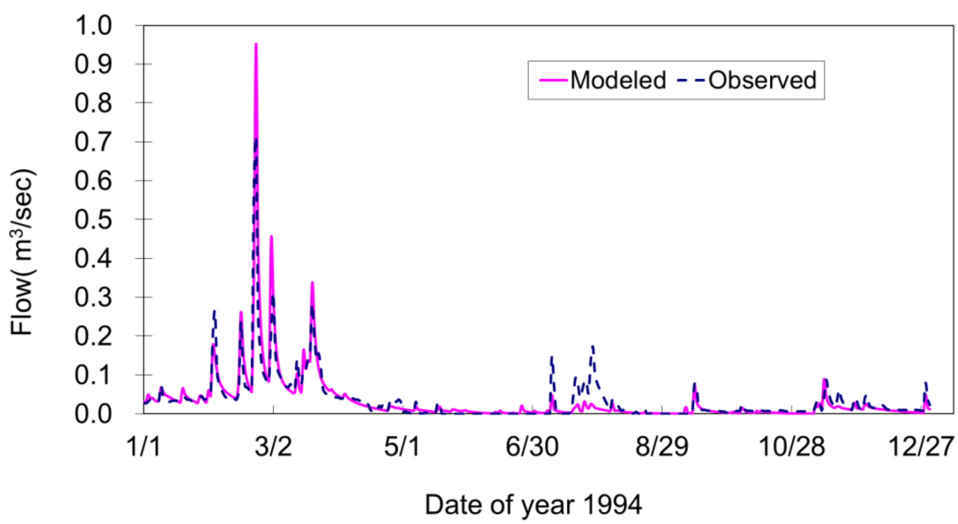

Figure 4.1: Time Series Comparison of Daily Stream Flow between Model Simulation and Observations from USGS Stream Gage 01484800 in 1993

Numerical model calibration of enterococcus was conducted for the period of 1996-2005. Because the pathogen loading estimated and input to the watershed is based on fecal coliform, the loading is converted to enterococci based on the regression equation. The pathogen loadings input to the landuses were based on the source assessment. Various sources of bacteria were considered, including manure application, wildlife, livestock, pets, and human impact. The loads deposited on land surface and contributed to run-off can be quantified by build-up and wash-off rates. Because the bacteria loading on the watershed is estimated based on fecal coliform production rates, the following translator equation (VA-DEQ, 2003, 2008) was used to convert output fecal coliform concentrations to enterococci concentrations:

$$\log_2(Enterococci) = 1.2375 + 0.59984 \times \log_2(Fecal\ Coliform)$$

Enterococci loading was computed according to the enterococci concentration and corresponding flow simulated by watershed model. Daily watershed run-off was discharged to the surface of the Finney Creek from adjacent watersheds and small creeks connected to it. Because bacteria observations were conducted inside the Creek, a linked watershed-receiving water model approach was conducted for the model conducted based on the observations in the Creek. Because of tidal effect, bacterial loading from Rattrap watershed can be transported upstream to the Finney Creek-Upper during food period. Therefore, the model simulated both streams and mixing and tidal transport processes together. A constant decay of 1 per day was used for the bacterial loss in the stream. Model results are shown in Figure 4.2. It can be seen that model simulates the bacteria variations in the calibration period indicating that the model is capable of TMDL development. Bacteria variations over a ten-year period are persistent. The detailed model calibration and TMDL development are presented in Appendix A.

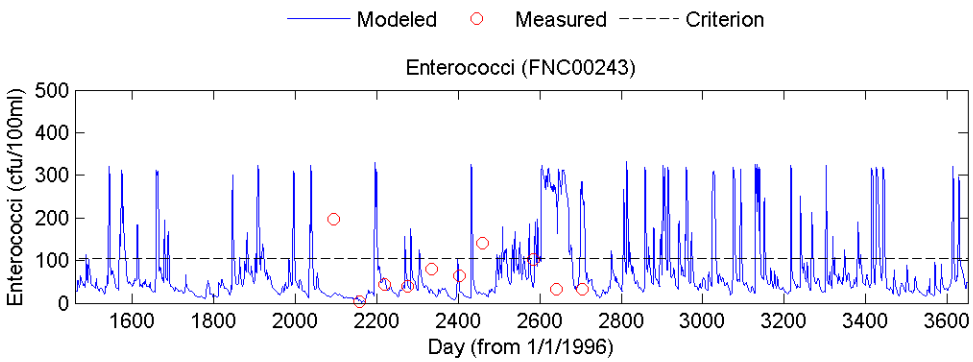

Figure 4.2: Time Series Comparison of Enterococci between Model Simulation and Observations from 1996 to 2005

4.4 Consideration of Critical Conditions and Seasonal Variation

EPA regulations at 40 CFR 130.7 (c)(1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of the waterbody is protected during times when they are most vulnerable. Critical conditions are important because they describe the factors that combine to cause a violation of WQSs and help to identify the actions that may have to be undertaken to meet WQSs.

The current loadings to the waterbody were determined using a long-term record of water quality monitoring (observation) data. The period of record for the data was 2001 to 2003, which spans different flow regimes and temperatures. A ten-year model simulation was conducted and model results show that concentration of bacteria variations were persistent over a 10-year period. The resulting estimate is quite robust. Seasonal variations involved changes in surface runoff, stream flow, and water quality as a result of hydrologic and climatologic patterns. These are accounted for by the use of this long-term simulation to estimate the current load and reduction targets.

4.5 Margin of Safety

To allocate loads while protecting the aquatic environment, a MOS needs to be considered. A MOS is typically expressed either as unallocated assimilative capacity or as conservative analytical assumptions used in establishing the TMDL (e.g., derivation of numeric targets, modeling assumptions or effectiveness of proposed controls). In the TMDL calculation, the MOS can either be explicitly stated as an additional separate quantity, or implicitly stated, as in conservative assumptions. For Finney Creek, an explicit MOS of 5% was included in the TMDLs.

4.6 TMDL Computation

According to the endpoints for enterococci for the established pollutant reduction target, the allowable enterococci loading reduction to meet enterococci criteria can be computed. A reduction of loadings from both Finney and Rattrap watersheds are needed due to the tidal effect. The load reduction needed for the attainment of the criteria was determined as follows:

$$\textbf{Load Reduction} = \frac{\textbf{Current Load} - \textbf{Allowable Load}}{\textbf{Current Load}} \times 100\%$$

The calculated results for enterococcus are listed in Tables 4.1.

Table 4.1: Estimated Loads and Load Reductions for Enterococci

	Pollutant	Criterion (CFU/100ml)	Current Load (counts/day)	Allowable Load (counts/day)	Required Reduction (%)
Finney Creek-Upper	Enterococci	104	2.71×10^{10}	7.97×10^{9}	70.6%
Rattrap Creek	Enterococci	104	6.43×10^{10}	2.08×10^{10}	67.7%

The loadings for each bacterial source were determined based on source assessment (Appendix B). Load allocation was determined by multiplying the total current and allowable loads by the representative percentage. The percent reduction needed to attain the water quality criterion was allocated to each source category. The results are presented in Table 4.2. The TMDL seeks to eliminate 100% of the human derived fecal component regardless of the allowable load determined through the LA process. Human-derived fecal coliforms are a serious concern in the estuarine environment and discharge of human waste is precluded by state and federal law. According to the preceding analysis, reduction of the controllable loads, human, livestock and pets, will not result in achievement of the water quality standard. Absent any other sources, the reduction is allocated to wildlife. The allocations presented demonstrate how the TMDLs could be implemented to achieve water quality standards; however, the state reserves the right to allocate differently, as long as consistency with the achievement of water quality standards is maintained.

Waterbody Name	Category	Current Load (Counts/Day)	Load Allocation (Counts/Day)	Reduction Needed (%)
Finney Creek-Upper	**Livestock**	2.67E+09	0.00E+00	100.0%
	Wildlife	2.41E+10	7.97E+09	67.0%
	Human	3.94E+06	0.00E+00	100.0%
	Pets	3.26E+08	0.00E+00	100.0%
	Total	2.71E+10	7.97E+09	70.6%
Rattrap Creek	**Livestock**	7.02E+09	0.00E+00	100.0%
	Wildlife	5.65E+10	2.08E+10	63.3%
	Human	9.23E+06	0.00E+00	100.0%
	Pets	7.64E+08	0.00E+00	100.0%
	Total	6.43E+10	2.08E+10	67.7%

Table 4.2: Load Allocation and Required Reduction for Enterococci for Each Source Category

4.7 Summary of TMDL and Load Allocation

There are no industrial or wastewater treatment facilities in the watershed of Finney Creek. The loads were allocated to the LA. The TMDLs are summarized in Table 4.3 below:

Table 4.3: Pathogens TMDL (counts/day)

Waterbody Name		TMDL	=	LA	+	WLA	+	FA	+	MOS (5%)
Finney Creek-Upper	Enterococci	7.97×10^{9}		7.49×10^{9}		n/a		7.97×10^{7}		3.98×10^{8}
Rattrap Creek	Enterococci	2.08×10^{10}		1.95×10^{10}		n/a		2.08×10^{8}		1.04×10^{9}

Where:

TMDL = Total Maximum Daily Load
LA = Load Allocation (Nonpoint Sources)
WLA = Wasteload Allocation (Point Sources)
FA = Future Allocation, which is 1% of allowable load
MOS = Margin of Safety

5.0 IMPLEMENTATION AND PUBLIC PARTICIPATION

5.1 General

Once a TMDL has been approved by the EPA, measures must be taken to reduce pollution levels from both point and nonpoint sources in the stream. For point sources, all new or revised Virginia Pollutant Discharge Elimination System (VPDES)/National Pollutant Discharge Elimination System (NPDES) permits must be consistent with the TMDL WLA pursuant to 40 CFR '122.44 (d)(1)(vii)(B) and must be submitted to EPA for approval. The measures for nonpoint source reductions, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the implementation plan. The process for developing an implementation plan has been described in the "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the DEQ and DCR TMDL project staff or at http://www.deq.virginia.gov/tmdl/implans/ipguide.pdf. With successful completion of implementation plans, local stakeholders will have a blueprint to restore impaired waters and enhance the value of their land and water resources. Additionally, development of an approved implementation plan may enhance opportunities for obtaining financial and technical assistance during implementation.

5.2 Staged Implementation

In general, Virginia intends for the required pollutant reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. For example, in agricultural areas of the watershed, BMP technology can be used to reduce the runoff of bacteria discharging to the Creek. It will be efficient to remove the livestock impact. Additionally, in both urban and rural areas, reducing the human loading from failing septic systems should be a primary implementation focus because of its health implications. This component could be implemented through education on septic tank pump-outs as well as a septic system repair/replacement program and the use of alternative waste treatment systems.

The iterative implementation of BMPs in the watershed has several benefits:

1. To enable tracking of water quality improvements following BMP implementation through follow-up stream monitoring;

2. To provide a measure of quality control, given the uncertainties inherent in computer simulation modeling;

3. To provide a mechanism for developing public support through periodic updates on BMP implementation and water quality improvements;

4. To help to ensure that the most cost-effective practices are implemented first; and

5. To allow for the evaluation of the adequacy of the TMDL in achieving WQSs.

Watershed stakeholders will have the opportunity to participate in the development of the TMDL implementation plan.

5.3 Reasonable Assurance for Implementation

5.3.1 Follow-Up Monitoring

Following the development of the TMDL, DEQ will make every effort to continue to monitor the impaired stream in accordance with its ambient monitoring program. DEQ's Ambient Watershed Monitoring Plan for conventional pollutants calls for watershed monitoring to take place on a rotating basis, bi-monthly for two consecutive years of a six-year cycle. In accordance with DEQ Guidance Memo No. 03-2004, during periods of reduced resources, monitoring can temporarily discontinue until the TMDL staff determines that implementation measures to address the source(s) of impairments are being installed. Monitoring can resume at the start of the following fiscal year, next scheduled monitoring station rotation, or where deemed necessary by the regional office or TMDL staff, as a new special study.

The purpose, location, parameters, frequency, and duration of the monitoring will be determined by the DEQ staff, in cooperation with DCR staff, the Implementation Plan Steering Committee, and local stakeholders. Whenever possible, the location of the follow-up monitoring station(s) will be the same as the listing station. At a minimum, the monitoring station must be representative of the original impaired segment. The details of the follow-up monitoring will be outlined in the Annual Water Monitoring Plan prepared by each DEQ Regional Office. Other agency personnel, watershed stakeholders, etc. may provide input on the Annual Water Monitoring Plan. These recommendations must be made to the DEQ regional TMDL coordinator by September 30 of each year.

DEQ staff, in cooperation with DCR staff, the Implementation Plan Steering Committee and local stakeholders, will continue to use data from the ambient monitoring stations to evaluate reductions in pollutants ("water quality milestones" as established in the IP), the effectiveness of the TMDL in attaining and maintaining WQSs, and the success of implementation efforts. Recommendations may then be made, when necessary, to target implementation efforts in specific areas and continue or discontinue monitoring at follow-up stations.

In some cases, watersheds will require monitoring above and beyond what is included in DEQ's standard monitoring plan. Ancillary monitoring by citizens', watershed groups, local government, or universities is an option that may be used in such cases. An effort should be made to ensure that ancillary monitoring follows established quality assurance/quality control (QA/QC) guidelines in order to maximize compatibility with DEQ monitoring data. In instances where citizens' monitoring data is not available and additional monitoring is needed to assess the effectiveness of targeting efforts, TMDL staff may request of the monitoring managers in each regional office an increase in the number of stations or that they monitor existing stations at a higher frequency in the watershed. The additional monitoring beyond the original bi-monthly single station monitoring will be contingent on staff resources and available laboratory budget. More information on citizen monitoring in Virginia and QA/QC guidelines is available at http://www.deq.virginia.gov/cmonitor/.

To demonstrate that the watershed is meeting WQSs for watersheds where corrective actions have taken place (whether or not a TMDL or TMDL Implementation Plan has been completed), DEQ must meet the minimum data requirements from the original listing station or a station representative of the originally listed segment. The minimum data requirement for conventional pollutants (bacteria, DO, etc.) is bi-monthly monitoring for two consecutive years. For biological monitoring, the minimum requirement is two consecutive samples (one in the spring and one in the fall) in a one-year period.

5.3.2 Regulatory Framework

While Section 303(d) of the CWA and current EPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the LAs and WLAs can and will be implemented. EPA also requires that all new or revised NPDES permits must be consistent with the TMDL WLA pursuant to 40 CFR §122.44 (d)(1)(vii)(B). All such permits should be submitted to EPA for review.

Additionally, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (the "Act") directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section 62.1-44.19.7). The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain WQSs, monitoring plans and milestones for attaining WQSs.

For the implementation of the WLA component of the TMDL, the Commonwealth intends to utilize the VPDES program, which typically includes consideration of the WQMIRA requirements during the permitting process. Requirements of the permit process should not be duplicated in the TMDL process, and with the exception of stormwater-related permits, permitted sources are not usually addressed during the development of a TMDL implementation plan.

For the implementation of the TMDL's LA component, a TMDL implementation plan addressing at a minimum the WQMIRA requirements will be developed. An exception is the municipal separate storm sewer systems (MS4s), which are both covered by NPDES permits and expected to be included in TMDL implementation plans, as described in the stormwater permit section below. Watershed stakeholders will have opportunities to provide input and to participate in the development of the TMDL implementation plan. Regional and local offices of DEQ, DCR, and other cooperating agencies are technical resources to assist in this endeavor.

In response to a Memorandum of Understanding (MOU) between the EPA and DEQ, DEQ also submitted a draft Continuous Planning Process to EPA in which DEQ commits to regularly updating the Water Quality Management Plans (WQMPs). Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

DEQ staff will present both EPA-approved TMDLs and TMDL implementation plans to the State Water Control Board for inclusion in the appropriate WQMP, in accordance with the CWA's Section 303(e) and Virginia's Public Participation Guidelines for Water Quality Management Planning.

DEQ staff will also request that the State Water Control Board (SWCB) adopt TMDL WLAs as part of the Water Quality Management Planning Regulation (9VAC 25-720), except in those cases when permit limitations are equivalent to numeric criteria contained in the Virginia WQSs. This regulatory action is in accordance with §2.2-4006A.4.c and §2.2-4006B of the Code of Virginia. SWCB actions relating to water quality management planning are described in the public participation guidelines referenced above and can be found on DEQ's website under http://www.deq.state.va.us/tmdl/pdf/ppp.pdf

5.3.3 Implementation Funding Sources

Cooperating agencies, organizations and stakeholders must identify potential funding sources available for implementation during the development of the implementation plan in accordance with the "Virginia Guidance Manual for Total Maximum Daily Load Implementation Plans". Potential sources for implementation may include the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, EPA Section 319 funds, the Virginia State Revolving Loan Program, Virginia Agricultural Best Management Practices Cost-Share Programs, the Virginia Water Quality Improvement Fund, tax credits and landowner contributions.

The TMDL Implementation Plan Guidance Manual contains additional information on funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

5.4 Public Participation

The development of the TMDL would not have been possible without public participation. The first public meeting was held at the Accomack County on March 28, 2012 at Accomack-Northampton Planning District Commission, 23372 Front St., Accomack, VA

23301, on the Eastern Shore of Virginia. The public meeting informs the stakeholders of the TMDL development process and is intended to obtain feedback. Results of the hydrologic calibration, bacteria source estimates, and TMDL development were discussed in the public meeting. The second meeting was held on July 18 at same location. Updated source distribution and TMDL was presented and discussed.

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Appendix A: Model Development

A.1 Model Development

Numerical models are widely used for TMDLs and other water quality studies. In this study, a system of numerical models was developed to simulate the loadings of bacteria, and the resulting response of in-stream bacteria transport and fate. The modeling system consists of two individual model components: the watershed model and the hydrodynamic-transport model. The watershed model LSPC, developed by the USEPA, was selected to simulate bacteria loads to the receiving waterbody of Finney Creek. The EFDC (Hamrick, 1992a; Park *et al*., 1995) was used to simulate the water quality of the receiving water.

A.1.1 Model Description

A.1.1.1 Watershed Model

The LSPC model is a stand-alone, personal computer-based watershed modeling program developed in Microsoft C^{++} (Shen *et al*., 2005). It includes selected Hydrologic Simulation Program FORTRAN (HSPF) algorithms for simulating hydrology, sediment, and general water quality on land, as well as a simplified stream transport model (USEPA, 2004; Shen *et al.*, 2002a, b; USEPA, 2001a, b). Like other watershed models, LSPC is a precipitation-driven model and requires necessary meteorological data as model input.

LSPC was configured for the Finney Creek watershed to simulate this watershed of 22 hydrologically connected subwatersheds (Figure A-1). The subwatersheds were used as modeling units for the simulation of flow and pathogen deposition on the watershed. LSPC was used to simulate the freshwater flow and its associated nonpoint source pollutants. The simulated freshwater flow and pathogen loadings for each subwatershed were fed into the adjacent water quality model segments. In simulating nonpoint source pollutants from the watershed, LSPC uses a traditional buildup and washoff approach. Pollutants from various sources (manure, wildlife, septic systems, etc.) accumulate on the land surface and are subject to runoff during rain events. Different land uses are associated with various anthropogenic and natural processes that determine the potential pollutant load. The pollutants contributed by interflow and groundwater are also modeled in LSPC for each land use category. Pollutant loadings from surface runoff, interflow, and groundwater outflow are combined to form the final loading output from LSPC. In summary, nonpoint sources from the watershed are represented in the model as landuse-based runoff from the landuse categories to account for their contribution (USEPA, 2001a).

For this study, the watershed processes were simulated based on buildup and washoff processes. The final loads were converted to model accumulation rates (ACQOP, units of counts/acre/day for pathogen). The ACQOP can be calculated for each land use based on all sources contributing nutrients to the land surface. For example, croplands receive manure application and feces from wildlife. Summarizing all these sources together can derive the accumulation rates for croplands. These loading parameters were adjusted accordingly during model calibration. The loads discharged to the stream were estimated based on model simulation results. The other two major parameters governing bacteria simulation, the maximum storage limit (SQOLIM, units in lb/acre/day for nutrients or counts/acre/day) and the washoff rate (WSQOP, unit in inches/hour), were specified based on soil characteristics and land use practices, and further adjusted during the model calibration. The WSQOP is defined as the rate of surface runoff that results in 90% removal of pollutants in one hour. The lower the value, the more easily washoff occurs.

A.1.1.2 Hydrodynamic Model

Hydrodynamic transport is the essential dynamic for driving the movement of dissolved and particulate substances in aquatic waters. Hydrodynamic models are used to represent transport patterns in complex aquatic systems. For the Finney Creek study, the EFDC model was selected to simulate hydrodynamics. EFDC is a general purpose modeling package for simulating 1-, 2-, and 3-dimensional flow and transport in surface water systems including: rivers, lakes, estuaries, reservoirs, wetlands, and oceanic coastal regions. It was originally developed at the Virginia Institute of Marine Science for estuarine and coastal applications and is considered public domain software (Hamrick, 1992a,1992b). The model code has been extensively tested and documented. The EFDC model has been integrated into the EPA's TMDL Modeling Toolbox for supporting TMDL development (http://www.epa.gov/athens/wwqtsc/html/hydrodynamic_models.html).

Inputs to the EFDC model for Finney Creek include:

- Bathymetry
- Freshwater inputs (lateral and up-stream) from watersheds
- Surface meteorological parameters such as wind
- Bacteria loadings from watershed

The model uses a grid to represent the study area (Figure A-1). The grid is comprised of cells connected through the modeling process. The scale of the grid (cell size) determines the level of resolution in the model and the model efficiency from an operational perspective. The smaller the cell size, the higher the resolution and the lower the computational efficiency. The model grid used for Finney Creek was developed based on the high-resolution shoreline digital files from USEPA and USGS topographic maps. The grid covered the entire Creek so that the mouth of the Creek can be used to set the boundary condition. Setting the model boundary well outside the model area of interest increased the model accuracy by reducing the influence of the boundary condition. There are a total of 94 cells in the horizontal surface grid.

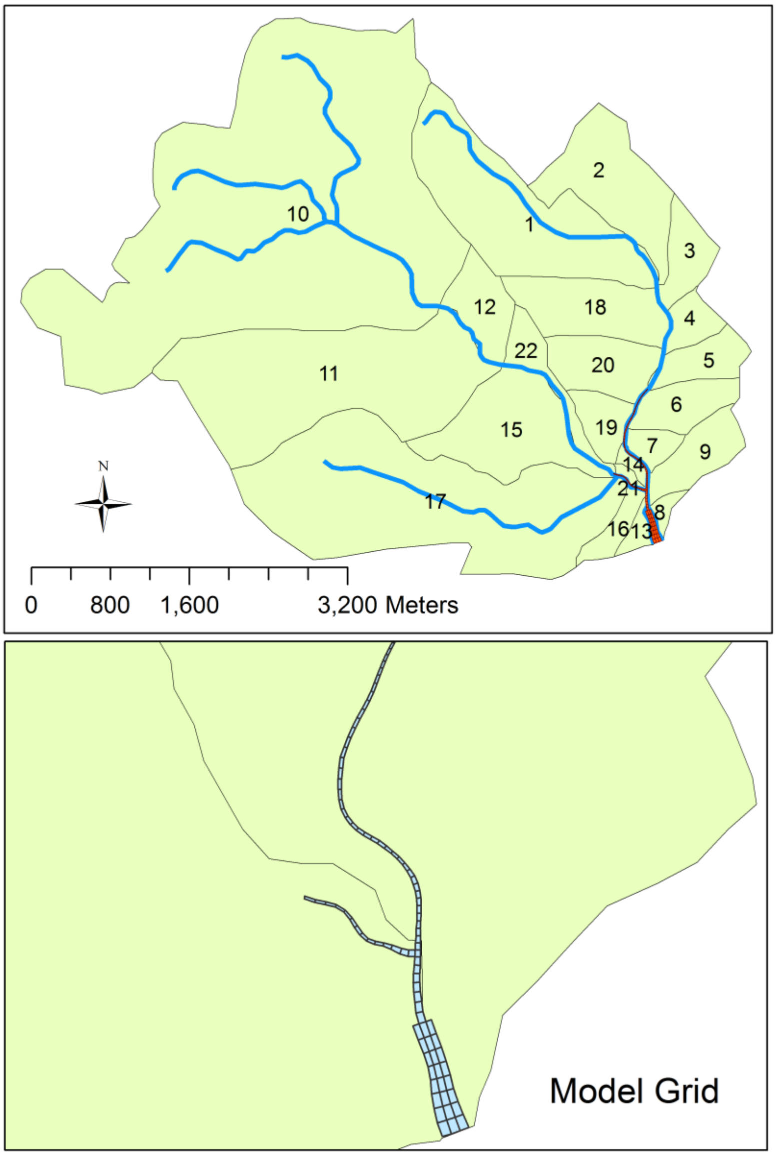
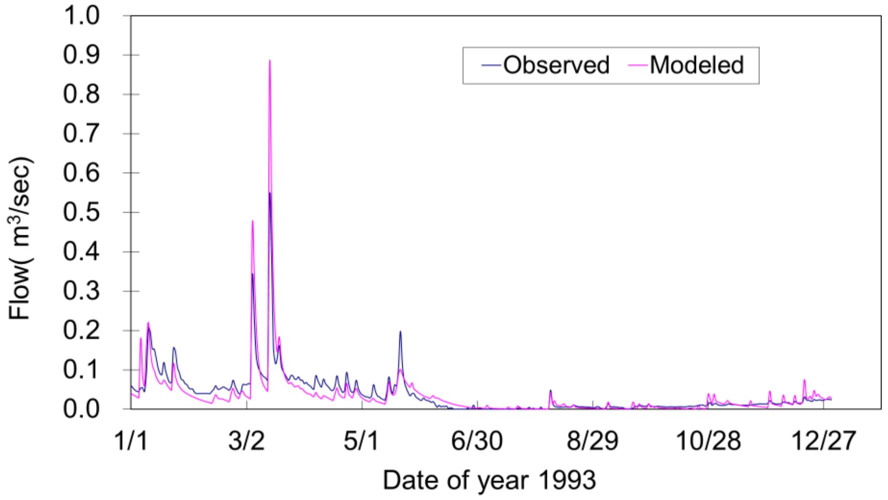


Figure A-1: A Map of Subwatersheds and Model Grid.

A.1.2 Model Calibration and Verification

A.1.2.1 Watershed Model

The calibration process involved adjustment of the model parameters used to represent the hydrologic processes until acceptable agreement between simulated flows and field measurements were achieved. Since there is no USGS gage or any other continuous flow data available in the Finney Creek watershed, a reference watershed was used for calibration. The USGS Gage 01484800 in Guy Creek near Nassawadox, VA, located approximately 14.8 mile south of the Finney Creek Watershed, was used to calibrate the model parameters for hydrology simulation. The derived parameters were further verified with local flow data collected by the VADEQ in the Onancock Creek watershed. The Onancock Creek watershed has similar landuse, soil, and characteristics to Finney Creek. Figure A-2 shows the time series comparison of daily stream flow for years 1993 and 1994. Figure A-3 shows the 10-year daily stream flow frequency comparison between the model result and field data collected by the USGS gage. Based on the comparison, it can be seen that LSPC has reasonably reproduced the observed flow over a 10-year period.



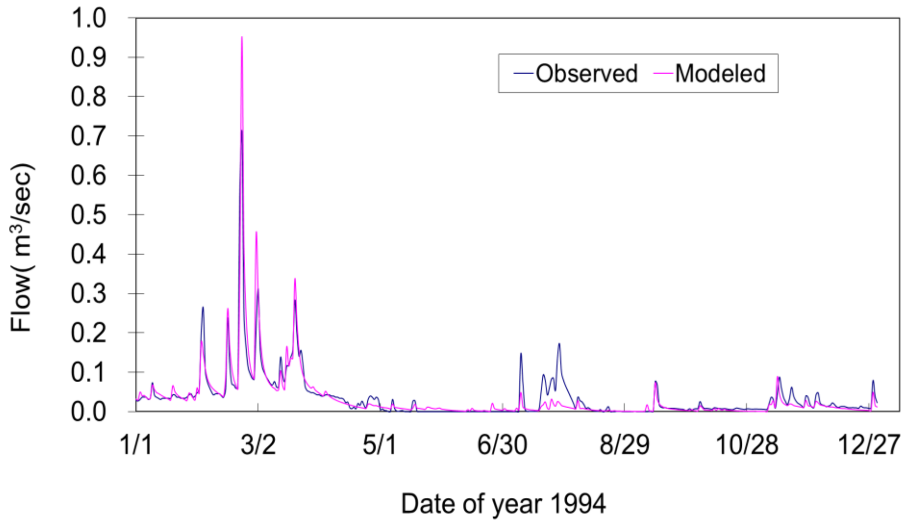


Figure A-2: Time Series Comparison of the Daily Stream Flow between Model Simulation and Observed Data from USGS Stream Gage 01484800 in 1993 and 1994

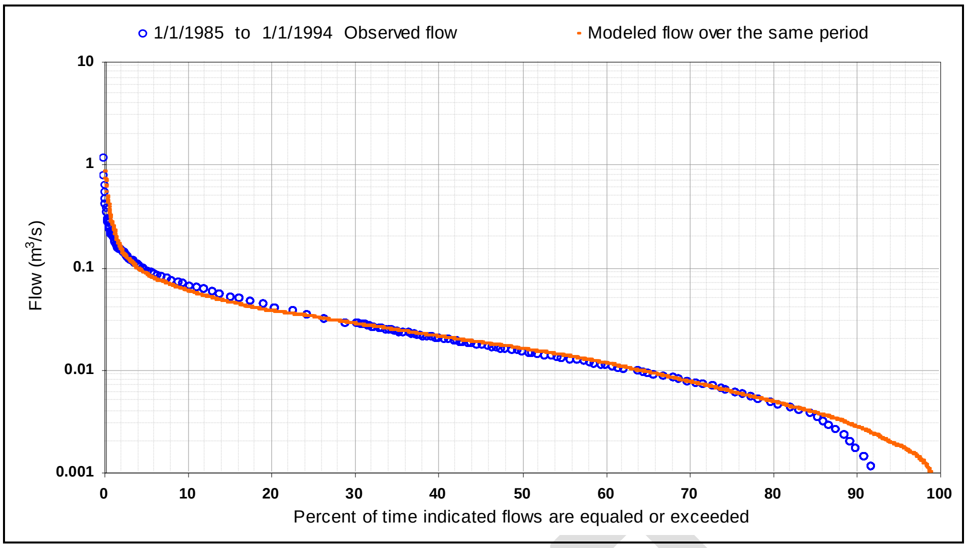


Figure A-3: 10-year Accumulated Daily Stream Flow Comparison between Model Simulation and the Reference Flow Station USGS 01484800

Calibration of the bacteria transport model is typically performed using water quality measurements from the watershed. Absent the necessary data from Finney Creek watershed, the calibration was performed on the observation data in Finney Creek receiving water using an iterative approach between the watershed model and receiving water model. The watershed model parameters (accumulation and loss rates) for bacteria associated with surface runoff of each land use category were estimated on the basis of all available field survey data using USEPA recommended loading production rates (USEPA, “FecalTool.xls” program, 1998). A ten-year model simulation (1996-2005) was conducted. A constant bacteria decay rate of 1/day is used, which was derived based upon observations and literature review (Shen and Zhao, 2010).

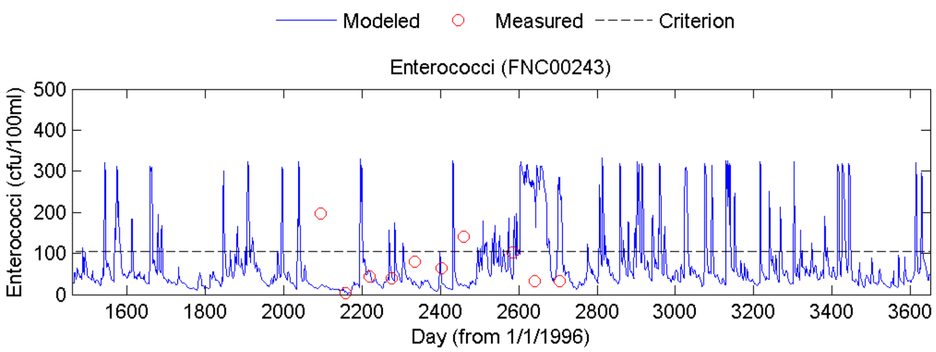


Figure A-4: Model Calibration of Enterococci at Station FNC00243

A.2 Current and Allocable Load

A.2.1 Allowable Load

A ten-year model simulation from 1996 to 2005 was selected to represent the current condition loadings. According to the enterococci endpoint, a series of loading reduction were conducted to find the allowable loads to evaluate the attainment of acceptable in-stream water quality. Because bacteria transported from the adjacent watershed (Rattrap Creek) will be transported upstream to the upper Finney Creek due to tidal, bacteria loadings from both watersheds need to be reduced. With about 70% reduction of enterococci loadings from both watershed, the water quality standards can be attained. The distribution of instantaneous enterococci is shown in Figure A-5.

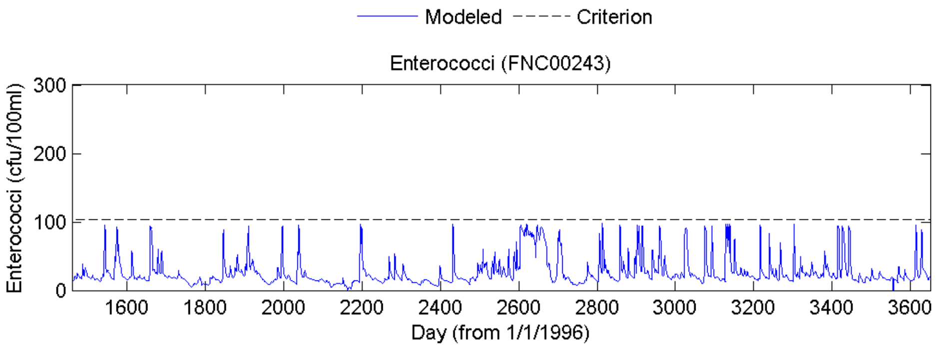


Figure A-5: Model Results of Enterococci Distribution at Station FNC00243 after 70% reduction of total loadings

The loadings for each bacterial source were determined based on source assessment (Appendix B). Load allocations were determined by multiplying the total current and allowable loads by the representative percentage. The percent reduction needed to attain the water quality criterion was allocated to each source category. The results are presented in Table A-1.

The TMDL seeks to eliminate 100% of the human-derived fecal component regardless of the allowable load determined through the LA process. Human-derived fecal coliforms are a serious concern in the estuarine environment and discharge of human waste is precluded by state and federal law. According to the preceding analysis, reduction of the controllable loads, human, livestock and pets, will not result in achievement of the water quality standard. Absent any other sources, the reduction is allocated to wildlife. The allocations presented demonstrate how the TMDLs could be implemented to achieve water quality standards; however, the state reserves the right to allocate differently, as long as consistency with the achievement of water quality standards is maintained.

Table A-1. Load Allocation and Required Reduction for Enterococci

Waterbody Name	**Category**	**Current Load (Counts/Day)**	**Load Allocation (Counts/Day)**	**Reduction Needed** (%)
Finney Creek-Upper	**Livestock**	2.67E+09	0.00E+00	100.0%
	Wildlife	2.41E+10	7.97E+09	67.0%
	Human	3.94E+06	0.00E+00	100.0%
	Pets	3.26E+08	0.00E+00	100.0%
	Total	2.71E+10	7.97E+09	70.6%
Rattrap Creek	**Livestock**	7.02E+09	0.00E+00	100.0%
	Wildlife	5.65E+10	2.08E+10	63.3%
	Human	9.23E+06	0.00E+00	100.0%
	Pets	7.64E+08	0.00E+00	100.0%
	Total	6.43E+10	2.08E+10	67.7%

Appendix B: Calculation of Population Numbers

The process used to generate population numbers used for the nonpoint source contribution analysis for the four source categories (human, livestock, pets, and wildlife) is described for each below.

B.1 Human

The number of people contributing fecal coliform from failing septic tanks were estimated in two ways and then compared to determine a final value.

1) Deficiencies (septic failures) from the DSS shoreline surveys were counted for each watershed and multiplied by 3 (average number of people per household).

2) Numbers of households in each watershed were determined from US Census Bureau data. The numbers of households were multiplied by 3 (average number of people per household) to get the total number of people and then multiplied by a septic failure rate* to get number of people contributing fecal coliform from failing septic tanks.

*The septic failure rate was estimated by dividing the number of deficiencies in the watershed by the total households in the watershed. The average septic failure rate was 12% and this was used as the default unless the DSS data indicated that septic failure was higher.

B.2 Livestock

US Census Bureau data were used to calculate the livestock values. The numbers for each type of livestock (cattle, swine, sheep, chickens (big and small), and horses) were reported by county. Each type of livestock was assigned to the landuse(s) it lives on, or contributes to by the application of manure, as follows:

Cattle	Cropland and Pastureland
Swine	Cropland
Sheep	Pastureland
Chickens	Cropland
Horses	Pastureland

Geographic Information System (GIS) was used to overlay data layers for several steps:

1) The county boundaries and the landuses to get the area of each landuse in each county. The number of animals was divided by the area of each landuse for the county to get an animal density for each county.

2) The subwatershed boundaries and the landuses to get the area of each landuse in each subwatershed.

3) The county boundaries and the subwatershed boundaries to get the area of each county in each subwatershed.

Using MS Access, for each type of livestock, the animal density by county was multiplied by the area of each landuse by county in each subwatershed to get the number of animals in each subwatershed. The number of animals in each subwatershed was summed to get the total number of animals in each watershed.

B.3 Pets

The dog population was calculated using a formula for estimating the number of pets using national percentages, reported by the American Veterinary Association:
dogs = # of households * 0.58. US Census Bureau data provided the number of households by county. The number of dogs per county was divided by the area of the county to get a dog density per county. GIS was used to overlay the subwatershed boundaries with the county boundaries to get the area of each county in a subwatershed. Using MS Access, the area of each county in the subwatershed was multiplied by the dog density per county to get the number of dogs per subwatershed. The number of dogs in each subwatershed was summed to get the total number of dogs in each watershed.

B.4 Wildlife

B.4.1 Deer

The numbers of deer were calculated using information supplied by DGIF, consisting of an average deer index by county and the formula:
#deer/mile^2 of deer habitat = (-0.64 + (7.74 * average deer index))
Deer habitat consists of forests, wetlands, and agricultural lands (crop and pasture). GIS was used to overlay data layers for the following steps:

1) The county boundaries and the subwatershed boundaries to get the area of each county in each subwatershed.
2) The subwatershed boundaries and the deer habitat to get the area of deer habitat in each subwatershed.

Using MS Access, the number of deer in each subwatershed was calculated by multiplying the #deer/mile^2 of deer habitat times the area of deer habitat. The number of deer in each subwatershed was summed to get the total number of deer in each watershed.

B.4.2 Ducks and Geese

The data for ducks and geese were divided into summer (April through September) and winter (October through March).

Summer

The summer numbers were obtained from the Breeding Bird Population Survey (US Fish and Wildlife Service) and consisted of bird densities (ducks and geese) for 3 regions: the southside of the James River, the rest of the tidal areas, and the salt marshes in both areas. The number of ducks and geese in the salt marshes were distributed into the other 2 regions based on the areal proportion of salt marshes in them using the National Wetland Inventory data and GIS.

Winter

The winter numbers were obtained from the Mid-Winter Waterfowl Survey (USFWS) and consisted of population numbers for ducks and geese in several different areas in the tidal region of Virginia. MS Access was used to calculate the total number of ducks and geese in each area and then these numbers were grouped to match the 2 final regions (Southside and the rest of tidal Virginia) for the summer waterfowl populations.

Data from DGIF showed the spatial distribution of ducks and geese for 1993 and 1994. Using this information and GIS, a 250-m buffer on each side of the shoreline was generated and contained 80% of the birds. Wider buffers did not incorporate significantly more birds, since they were located too far inland. GIS was used to overlay the buffer and the watershed boundaries to calculate the area of buffer in each watershed. To distribute this information into each subwatershed, GIS was used to calculate the length of shoreline in each subwatershed and the total length of shoreline in the watershed.

Dividing the length of shoreline in each subwatershed by the total length of shoreline gives a ratio that was multiplied by the area of the watershed to get an estimate of the area of buffer in each subwatershed. MS Excel was used to multiply the area of buffer in each subwatershed times the total numbers of ducks and geese to get the numbers of ducks and geese in each subwatershed. These numbers were summed to get the total number of ducks and geese in each watershed. To get annual populations, the totals then were divided by 2, since they represent only 6 months of habitation (this reduction underestimates the total annual input from ducks and geese, but is the easiest conservative method to use since the model does not have a way to incorporate the seasonal differences).

B.4.3 Raccoons

Estimates for raccoon densities were supplied by DGIF for 3 habitats—wetlands (including freshwater and saltwater, forested and herbaceous), along streams, and upland forests. GIS was used to generate a 600-ft buffer around the wetlands and streams, and then to overlay this buffer layer with the subwatershed boundaries to get the area of the buffer in each subwatershed. GIS was used to overlay the forest layer with the subwatershed boundaries to get the area of forest in each subwatershed. MS Access was used to multiply the raccoon densities for each habitat times the area of each habitat in each subwatershed to get the number of raccoons in each habitat in each subwatershed. The number of raccoons in each subwatershed was summed to get the total number of raccoons in each watershed.